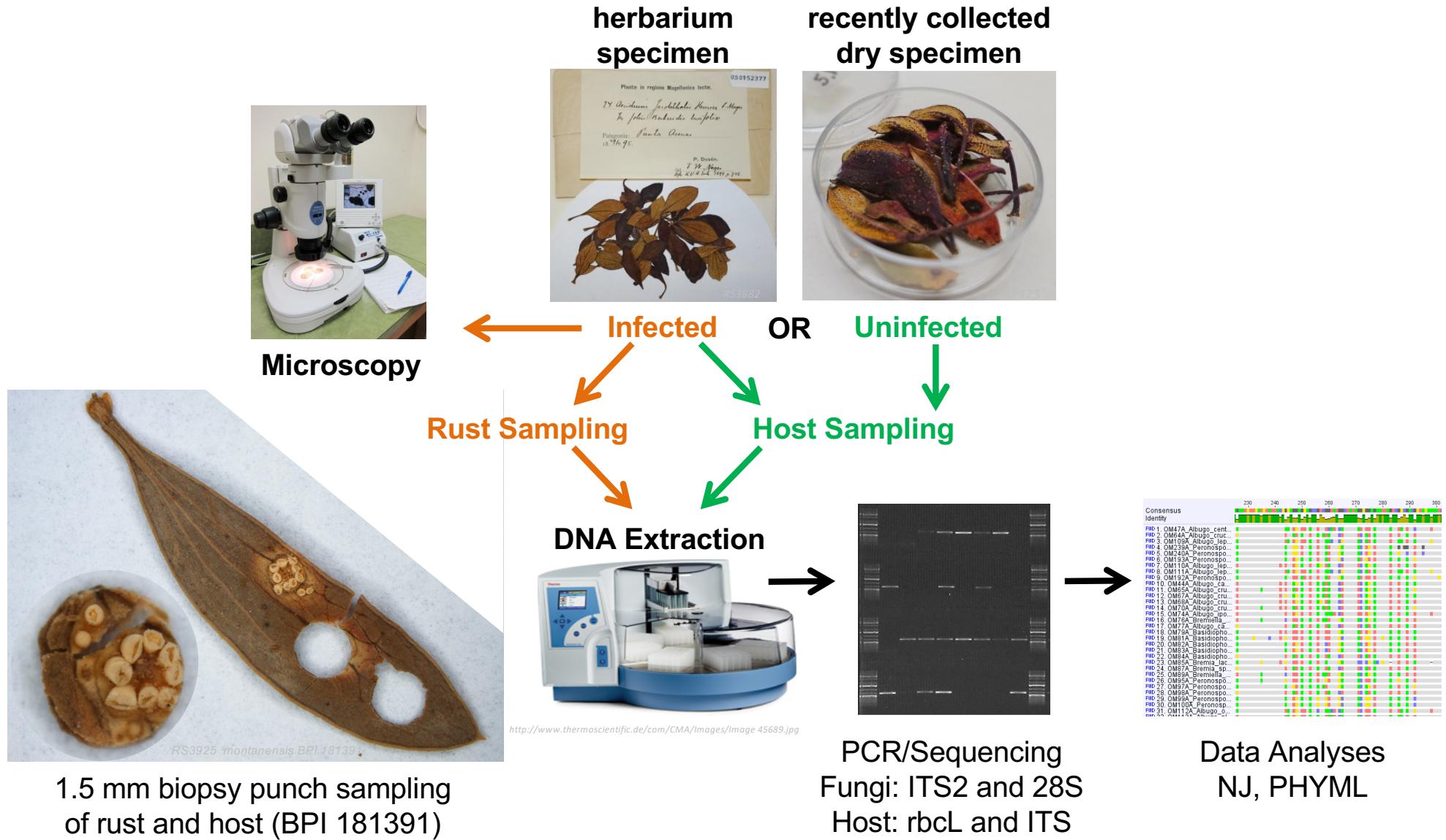




Rusts and Bunts: reference DNA sequences, systematics, diagnostics

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Reference DNA sequences: sampling herbarium specimens



Reference DNA sequences: sampling herbarium specimens

Herbarium Code	Rust Specimens Sampled
DAOM (AAFC)	1960
BPI (USDA-ARS)	488
PUR (Purdue University)	568
others: S, B, BP, BR, HMAS, K, MA, PHO, PRC, PRM	140
new collections	500
	3656

ITS2
and
partial
28S

RS3386A_Uromyces_triquetus_1999_Hypericum_majus_Canada_226327
RS3387A_Uromyces_triquetus_1963_Hypericum_sp_Canada_115014
RS3389A_Uromyces_triquetus_1981_Hypericum_virginicum_Canada_184420
RS3388A_Uromyces_triquetus_1956_Hypericum_virginicum_Canada_184416
RS3407A_Uromyces_sparganii_1964_Acorus_calamus_USA_107694
RS3409A_Uromyces_sparganii_1962_Sparganium_eurycarpum_USA_90205
RS3367A_Uromyces_dianthi_1941_Dianthus_caryophyllus_Canada_7346
RS3372A_Uromyces_dianthi_1915_Tunica_saxifraga_Switzerland_79257
RS3370A_Uromyces_dianthi_1920_Euphorbia_seguieriana_Germany_79256
RS3393A_Uromyces_houstoniatus_1954_Houstonia_caerulea_Canada_45927
RS3392A_Uromyces_houstoniatus_1958_Houstonia_caerulea_Canada_75335
RS3395A_Uromyces_houstoniatus_1935_Sisyrinchium_augustifolium_Canada
RS3364A_Uromyces_asclepiadis_1969_Asclepias_syriaca_USA_138238
RS3366A_Uromyces_asclepiadis_1943_Asclepias_syriaca_USA_14009
RS3365A_Uromyces_asclepiadis_1962_Asclepias_syriaca_USA_90202

Uromyces triquetus – *Hypericum* (St. John's wort)

Uromyces sparganii – *Acorus* & *Sparganium*

Uromyces dianthi – *Euphorbia* ↔ *Caryophyllaceae*

Uromyces houstoniatus – *Houstonia* ↔ *Sisyrinchium*

Uromyces asclepiadis – *Asclepias* (milkweed)

Systematics: 2010-2019 grass rust species complexes

In collaboration with Miao Liu (all), USDA (James Kolmer,
** Lisa Castlebury) and others*

Puccinia striiformis (stripe rusts) Liu M, Hambleton S. 2010. Fungal Biology 114:881-899.

- new Series, 3 synonymized species recognized

Puccinia graminis (stem rusts) Liu M, Hambleton S. 2012. Mycologia 104:1056-1067.

- new closely related species: *P. chunjiei*

Puccinia coronata (crown rusts) Liu M, Hambleton S. 2013. Mycological Progress 12:63-89.

- new Series, 7 species recognized: 5 new, several unnamed

* *Puccinia recondita* (leaf rusts, focus on *Elymus*)

Liu M, Szabo LJ, Hambleton S, Anikster Y, Kolmer J. 2013. Plant Disease 97:1408-1417.

- six phylogenetic lineages: three are complexes

** *Panicum* (switchgrass) rusts Demers JE, Liu M, Hambleton S, Castlebury LA. 2017. Mycologia 109:1-17.

- six species recognized: four new

* *Rhamnus* rusts (microcyclic, related to crown rusts)

Hambleton S, Liu M, Eggertson Q, Wilson S, Carey J, Anikster Y, Kolmer J. 2019. Sydowia 71:47-63.

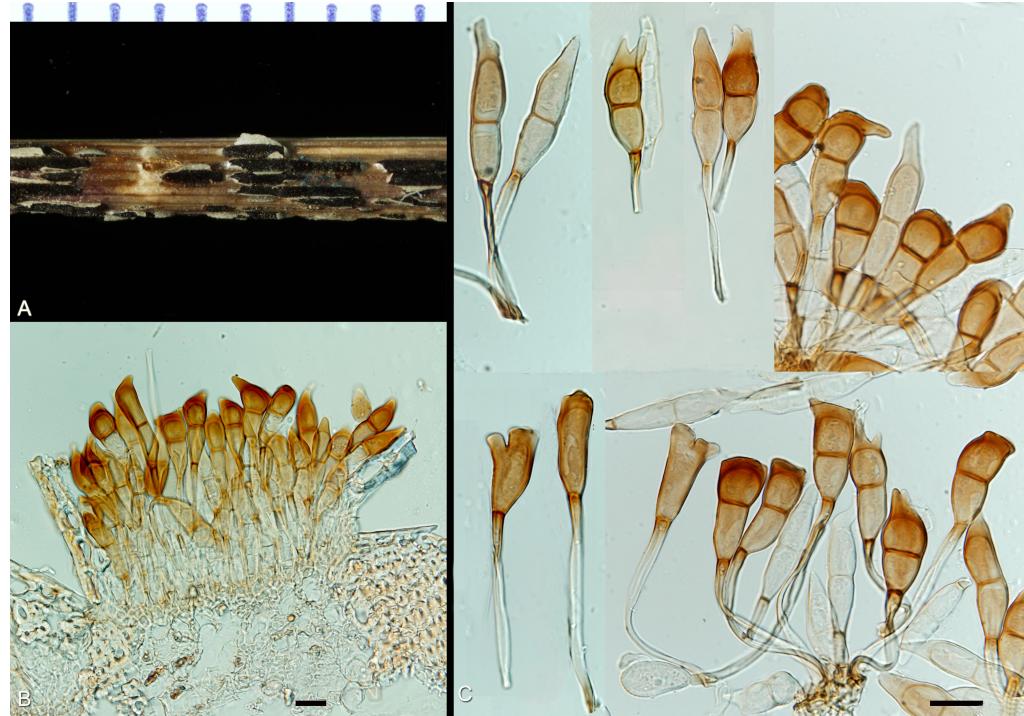
- 4 species recognized: two new

Systematics: grass rust species complexes



Puccinia chunjiei M. Liu, C.J. Li & Hambl. [as 'chunjii'],
Mycologia 104:1060 (2012).

- Microscopy
- Pathology
- Phylogenetics
- Taxonomic history
- Species concepts
- Nomenclature



Diagnostics – Rusts: real-time PCR, metagenomics, genotyping

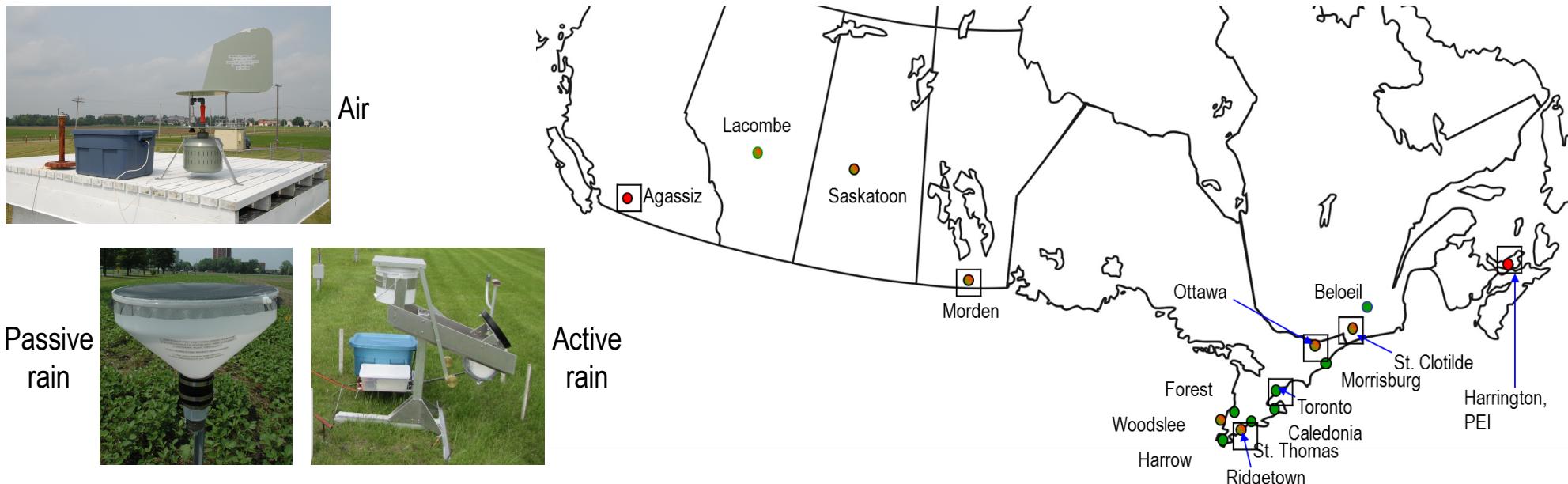
2007-2013 – Canadian spore trap network (federal & provincial support)

- Asian Soybean Rust qPCR
(with Les Szabo USDA and others)

Isard SA, Barnes CW, Hambleton S, Ariatti A, Russo JM, Tenuta A, Gay DA, Szabo LJ. 2011. Plant Disease 95(11):1346-1357.

- Biodiversity Metagenomics – contributing reference ITS
(with Wen Chen AAFC and others)

Chen W, Hambleton S, Seifert KA, Carisse O, Diarra MS, Peters RD, Lowe C, Chapados JT, Lévesque CA. 2018. Applied and Environmental Microbiology 84(9):e02601-17.



Diagnostics – Rusts: real-time PCR, metagenomics, genotyping

2015 – cereal rust qPCR assays developed .

- Targeting stripe rust and stem rust lineages on wheat
(with Miao Liu AAFC and others)

Hambleton S, Liu M, Eggertson Q, Wilson S, Carey J, Anikster Y, Kolmer J. 2019. Sydowia 71:47-63.

- First report stripe rust in Quebec

Rioux S, Mimee B, Gagnon A-È, Hambleton S. 2015. Phytoprotection 95:7-9.

2017 – First report stem rust race RRTTF in Ecuador
(with Les Szabo USDA and others)

Barnes CW, Ordóñez ME, Hambleton S, Dadej K, Szabo LJ, Fetch T. 2018. Plant Disease 102:448.

Diagnostics – Bunts (*Tilletia*): real-time PCR and genomics

Four species on wheat

Two subject to quarantine regulations

- Objective: molecular assays stringent enough for regulatory agencies
- 2019 – Ten genomes for five *Tilletia* species and candidate primers/probes (with Hai Nguyen AAFC and others)

Nguyen HDT, Sultana T, Kesanakurti P, Hambleton S. 2019. IMA Fungus 10:11.



wheat infected with
Tilletia controversa



Current research focus:

ITS reference sequences – for metagenomics and systematics studies

Leaf rusts of rye and wheat:

- *Puccinia recondita* – 52 synonyms, multiple lineages and complexes
- *Puccinia triticina* – some rusts on wheat are unrelated and unnamed

Tilletia: in collaboration with CFIA-Ottawa (Guillaume Bilodeau)

- qPCR assays for the wheat pathogens
- Dwarf bunt/common bunt species complex

Resources:

- USDA (previous action plan; Doug Luster & Gary Peterson) –
Tilletia-infected specimens, grain sub-samples tested for dwarf bunt
- Canada – historic *Tilletia* cultures acquired by CFIA, new Canadian dwarf bunt collections